Dispatches

Biology of Music: Another One Bites the Dust

Rhythmic entrainment, long believed an exclusive prerogative of humans, has now been demonstrated in several bird species, raising interesting questions about the evolutionary biology of music.

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We humans are fascinated by ourselves, and mythology and science alike overflow with debate over which specific traits make us unique. Claims that language, culture, music or technology, or more specific capacities like categorical perception or episodic memory, are 'uniquely human' frequently spur researchers to look more closely at nonhuman animals. Often, evidence of analogues in other species is uncovered as a result [1,2].

A mechanism frequently touted as uniquely human is rhythmic entrainment to music: the capacity to move one's limbs or body to a complex external 'beat'. Such entrainment is necessary for ensemble musical playing and dancing, is found in all human cultures, and has not previously been demonstrated in other animals [3,4]. In this issue, however, two papers [5,6] report evidence for entrainment to music in several bird species, toppling another claim of human uniqueness.

The leading acts in this new discovery are both celebrity parrots. The first, a cockatoo named 'Snowball', received over 2 million views of his debut YouTube video. When Snowball was donated to a bird rescue shelter, he was accompanied by a CD noting that he particularly liked the accompanying song. When the CD was played Snowball became excited and began to, well, *dance*. Snowball bobs to the beat, raises his legs periodically and erects his crest in a compellingly rhythmic performance. This YouTube video brought him to the attention of music researchers. Although many scientists were sceptical, Patel *et al.* [5] decided to find out for sure.

Using versions of Snowball's favourite song where the underlying beat was experimentally modified, Patel *et al.* [5] found that the cockatoo entrained by slowing down or speeding up his bobbing appropriately. Although Snowball's rhythm is not perfect — he goes in and out of synchrony — the team used Monte Carlo simulations to show that the bouts of entrainment are very unlikely to occur by chance. Thus, given a complex musical stimulus, at least one bird can extract the beat and entrain his movements to it.

The second paper in this issue broadens the sample considerably: Schachner *et al.* [6] studied the famous African Grey parrot 'Alex' (whose obituary, sadly, recently appeared in the New York Times) and showed that Alex could also entrain his head bobs to music. Most importantly, this paper pioneers a novel data-mining technique, using YouTube as a vast Internet database. Trolling through this online video service with search terms including 'dance' and animal names, they uncovered thousands of home-movies where dogs, rats, chimpanzees and many other species purportedly dance. After winnowing out fakes, and subjecting the remainder to periodicity analysis, their investigation led to a surprising result: with just one exception (an Asian elephant), the only species found to entrain to music were various species of parrots (members of the avian order Psittaciformes).

Although this list broadens the better-controlled findings of entrainment in Snowball and Alex, it also raises fascinating questions about the species that *aren't* on the list. The most obvious gaps are domesticated animals like dogs or horses: despite their pervasive exposure to music, not a single convincing demonstration of mammalian pet dancing was found. This negative evidence supports the everyday observation that dogs can't dance, and the outstanding question is why not. What is lacking?

Another group conspicuous by its absence are nonhuman primates. The absence of any true 'dancing chimpanzees' is surprising, not just because chimpanzees are our closest relatives but because they naturally engage in 'drumming' in the wild [7]. Chimpanzees often drum with their hands or feet on rainforest trees in the wild, generating far-carrying, quasi-rhythmic signals. Similarly, gorillas beat their bodies, and occasionally objects, with a rough 'beat'. Thus, our nearest living cousins exhibit a behaviour suggesting that some form of propensity to drum was present in our common ancestor, making the lack of evidence for ape entrainment surprising. But given that most humans do not interact with chimpanzees regularly, and that most chimpanzee owners (in entertainment or science) do not post videos online, this negative evidence does not yet provide compelling evidence of absence. An open mind concerning apes remains warranted.

The final guests missing at the entrainment party are a variety of other species that possess the capacity for complex vocal learning ('vocal mimicks'). Patel hypothesized that the human capacity for entrainment could be a by-product of the vocal learning mechanisms that allow us to learn speech sounds and musical melodies [8,9]. Vocal learning abilities have been known since Darwin's time to be shared by birds and humans, but to be weakly developed, or lacking entirely, in nonhuman primates [10]. Because both vocal learning and entrainment require cross-modal linkage between auditory and motor regions of the brain, Patel plausibly suggested that vocal mimicking might be a prerequisite of entrainment.

The results of Schachner *et al.* [6] support this hypothesis. But the data also indicate that, although apparently necessary, vocal, learning is not *sufficient* for auditory entrainment. Many other vocal-learning species, potentially available for human filming, do not show entrainment in the online database. These include other bird species commonly kept as pets, such as mynah birds or starlings, and marine mammals, such as dolphins and seals. Both are capable of vocal mimicry and often trained for public

performance. An absence of entrainment in such species would raise the question of what else is required for entrainment.

One possibility is the propensity to engage in joint social action. A recent study of entrainment in human children [11] showed that young children find it difficult to entrain to a purely auditory stimulus (a disembodied metronomic beat), or to a visible drumbeating robot. They nonetheless entrain with a human adult in a socially-engaged game-playing context. Perhaps a similar propensity for social engagement underlies the apparent capacity for parrots, but not other birds, to entrain to a beat?

Parrots are long-lived, group-living birds, and their open-ended learning abilities are sometimes employed to develop vocal 'badges' of group membership [12]. Although the adaptive functions of parrot vocalizations remain poorly understood, they appear to be more group-oriented than the mostly individual territorial and courtship displays that typify songbirds, and this may be one factor explaining the complete dominance of parrot species in the YouTube sample. This hypothesis also suggests, given the capacity of dolphins to engage in imitation and joint action [13], that the potential for entrainment in this species deserves a closer experimental look.

What are the implications of these animal findings for research on human music and its evolution? The first is that we now have animal models to further explore the neural and genetic basis for entrainment. The second illustrates the fundamental point that evolutionary convergence or 'analogy' allows us to test evolutionary hypotheses, such as the vocal mimicry hypothesis [14]. Homologous traits represent a single evolutionary event, and count statistically as a single datapoint. In contrast, when different clades evolve the same trait convergently, these constitute statistically independent events [15], allowing us to test hypotheses about the evolution of human music or language that might otherwise remain 'just-so-stories'. At both mechanistic and functional levels, then, the discovery of parrot entrainment provides a rich foundation for further advances in understanding the biology and evolution of human music.

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DOI: 10.1016/j.cub.2009.04.004

Chromosome Segregation: Ndc80 Can Carry the Load

Dynamic attachments between kinetochores and spindle microtubules are required for chromosome bi-orientation in mitosis. A new study provides biophysical insight into how the Ndc80 complex may contribute to the formation of these attachments.

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How cells generate the kinetochore–microtubule attachments required to drive chromosome movements in mitosis has long puzzled cell biologists. This problem is an interesting one, as attachments must be strong to generate forces for chromosome movements, yet flexible to allow for the constant gain and loss of tubulin subunits at the microtubule plus-ends. The search for molecular components that serve as load-bearing couplers between kinetochores and microtubules is active. Much effort has focused on the Ndc80 complex — composed of Ndc80 (Hec1 in humans), Nuf2, Spc24, and Spc25 — since it is essential for efficient kinetochore–microtubule attachment in cells and it can directly bind microtubules *in vitro* (reviewed in [1]). In budding yeast, the Ndc80 complex is thought to partner with the Dam1 complex to form kinetochore–microtubule attachments, perhaps through direct interaction [2]. Dam1 complexes are able to form rings and non-ring oligomers on microtubules *in vitro* [3,4], and both forms of assemblages can generate load-bearing attachments to growing and shortening microtubule plus-ends [5,6]. Although much evidence suggests that Dam1 complexes may serve as kinetochore–microtubule couplers, no convincing Dam1 homologs have surfaced in higher eukaryotes.

This raises the question: can the Ndc80 complex alone form load-bearing attachments to dynamic